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Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

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Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

December 1949 Vol. 2, No. 12

Communications and Queries

Concerning Rev. 974, August 1949, "On the motions of an oscillator under the influence of an on-off servomechanism."

Dr. I. Flügge-Lotz points out that she reported in the article on her joint work with H. F. Hodapp, K. Klotter, H. Meissinger and K. Scholz, and should not have been shown as the sole author of the paper. This oversight is the editor's fault. Ed.

Concerning Rev. 1014, August 1949, "Fatigue tests of manganese steel," by R. S. Jensen.

The reviewer (M. Hempel) points out that our translation of his review stated the test frequency as 800 cps instead of 800 cycles per minute, and omitted the information that the compressive stress at which the crack was initiated was determined in each test. Ed.

Query about a fracture-stress formula

Editor:

C. Bach (*Elasticitaet und Festigkeit*, 1902, pp. 479, 499) gives the equivalent of the following formula for the fracture stress of ring-shaped bodies:

$$S_{\max} = (F/s)(xy - x + y)/x(1 + x)(1 - y)$$

where F is the fracture load, s the difference between the outer and inner surface areas of the ring, y the ratio of the difference to the sum of the ring diameters, and $x = y^2/3 + y^4/5 + y^6/7 + \ldots$ Is this formula still regarded as correct and are there any later investigations on this subject?

Industrial Diamond Information Bureau, London

Addition to Rev. 1602, November 1948, "Universal equations of isothermal equilibrium etc.," by Ch. Platrier.

Three different (but of course equivalent) Lagrangian forms of the statical or dynamical equations for continuous media are due to Kirchhoff [*Akad. Wiss. Wien*, 1852, vol. 9, pp. 762–773, see p. 763]; Boussinesq [*Mem. Divers Savants*, 1872, vol. 20, pp. 509–615, see sect. I, eq. (3)]; and Signorini [*Rend. Lincei*, 1930, (6) vol. 12, pp. 411–416, see sect. 4]. A special case of a fourth form is due to Euler [*Novi Comm. Petrop.*, 1769, vol. 14, pp. 270–386, see sect. 119]. These equations recur frequently in the literature. A different form given by Deuker [*Deutsche Math.*, 1940–1941, vol. 5, pp. 546–562, eq. (8.7)] is false.

C. A. Truesdell, USA

Theoretical and Experimental Methods

(See also Revs. 1500, 1557)

1473. Joseph Fels Ritt, "Integration in finite terms," Columbia Univ. Press, New York, 1948. Cloth 5.7 × 8.8 in., 100 pp., $2.75.

This subject is of special practical interest because integration in terms of tabulated functions is frequently the simplest approach to numerical computation or to the discussion of behavior. Much time is wasted on attempts to guess the integral "in closed form." Liouville's theory of elementary methods leads to a systematic decision of this problem. Integrals of algebraic and transcendental functions are considered, followed by a discussion of integrability by quadratures of differential equations, especially those of the first order. Ed.

1474. S. E. Meekeladze, "Numerical integration of differential equations by means of summation formulas" (In Russian), *Notes Acad. Sci. USSR (Doklady Akad. Nauk SSSR)*, Mar. 11, 1949, vol. 65, pp. 125–128.

This paper contains a numerical method of integration of differential equations of the type $y^{(n)} = f(x,y,y' \ldots y^{(n-2)})$ by means of conventional higher-order summation formulas. The solution may be arranged in tabular form, and is illustrated by an example from which it is evident that dividing of the interval (0, 1) into five parts gives an error of 3.7 per cent.

M. M. Gololobov, Czechoslovakia

1475. Dino Dainelli, "On the numerical integration of ordinary differential equations" (in Italian), *R. C. Math. Appl.*, July-Dec. 1948, ser. 5, vol. 7, pp. 393–405.

The paper presents a new step-by-step method for the numerical integration of ordinary differential equations. The method is directly applicable to ordinary differential equations of order m, without the necessity of first reducing the equation to an equivalent normal system of m differential equations of the first order.

To solve the differential equation

$$y^{(m)}(x) = f(x,y,y', \ldots, y^{(m-1)})$$

with the initial conditions

$$y(x_0) = y_0,\ y'(x_0) = y'_0, \ldots,\ y^{(m-1)}(x_0) = y_0^{(m-1)},$$

over an interval beginning with x_0, the interval is uniformly subdivided at points x_s, $s = 0, 1, 2, \ldots$ at which the corresponding values of y and its derivatives are designated as $y_s, y'_s, y''_s, \ldots$ Fundamentally, then, the method expresses $y_{s+1}^{(i)}$, $i = 0, 1, \ldots, (m-1)$, as a Taylor series, stopping at the $(m-i)$th power, with a correction term. It differs, however, from the well-known method of solving differential equations by means of Taylor series not only in the presence of the correction term, but also in that the latter method usually employs series of powers higher than m and consequently requires that derivatives of $f(x,y,y', \ldots)$ be computed.

The series for $y_{s+1}^{(i)}$ is expressed linearly in terms of numbers $y_s^{(i)}, y_s^{(i+1)}, \ldots, y_s^{(m)}$, and differences between the numbers $y_0^{(m)}, y_1^{(m)}, \ldots, y_s^{(m)}$, by means of which values of y and its derivatives may be successively computed. The series is given in a form immediately suitable for numerical calculation. For illus-

tration the method is applied to solve a third-order differential equation.

The convergence of the method is demonstrated and expressions for limits of error are derived.

Of the numerous procedures that have been developed for integrating differential equations numerically, several authors have said that Adam's method is "one of the simplest" or "the best." Dainelli claims that his procedure is preferable because his method requires fewer tables of differences so that the calculations are less tedious. In this the reviewer concurs.

Louis Landweber, USA

1476. H. Unger, "A numerical method for initial-value problems in second-order ordinary equations" (in German), *Z. angew. Math. Mech.*, Aug.-Sept. 1947, vol. 25/27, pp. 135–136.

In the differential equation $d^2y/dt^2 + C(t)y = \sigma$ to which, in general, each linear homogeneous second-order differential equation can be reduced, $c > 0$, dc/dt and d^2c/dt^2 are assumed to be piecewise continuous. This equation is transformed into $d^2w/dx^2 + \{1 - q(x)\} w = \sigma$. Approximate stepwise solutions are developed by replacing $1 - q(x)$ by a step or polygon curve. Circular and hyperbolic functions are obtained by the first method, Bessel functions and Airy integrals by the second method. By means of the integral equation equivalent to the problem, the errors of the approximate solutions are estimated and two estimates for $|y|$ and $|dy/dt|$ are given. The author claims the developed method to be superior to other ones in many cases (e.g., the method of Runge-Kutta-Nystroem).

Manfred Schaefer, Germany

1477. F. Herzog and C. P. Wells, "A problem concerning orthogonal trajectories," *Quart. appl. Math.*, Apr. 1949, vol. 7, pp. 121–126.

The authors consider an interesting geometric property of two families of orthogonal trajectories (in a physical situation, such as heat flow, the two families would be the lines of heat flow and the isothermals respectively). The property considered is that of "proportional arc length." Let X and Y be two families of orthogonal trajectories. Then one of them, say X, is said to be of proportional arc length if the following condition is satisfied: Let Y_1, Y_2, Y_3 be any three curves of the family Y, and let s_1 be the arc length of any curve of the family X between Y_1, and Y_2, and s_2 the arc length of the same curve between Y_2 and Y_3 Then the ratio s_1/s_2 is to be constant for all curves of the family X, that is, it is dependent only on the choice of Y_1, Y_2, and Y_3.

The authors prove several theorems concerning families which are of proportional arc length. The main result is contained in a theorem that the totality of different families of proportional arc length can be obtained from the real and imaginary parts of the analytic functions (1) $w = z$, (2) $w = e^z$, (3) $w = \exp(ze^{i\gamma})$, where $0 < \gamma < \pi/2$, and (iv) $w = {}_0\int^z \exp(-t^2)dt$.

The results of this paper can be used in the step-by-step construction of two-dimensional heat-flow patterns.

Benjamin Epstein, USA

1478. B. N. Babkin, "Approximate solution of ordinary differential equations of any order by a method of successive approximations based on a theorem of S. A. Chaplygin on differential inequalities" (in Russian), *Notes Acad. Sci. USSR (Doklady Akad. Nauk SSSR)*, Jan. 21, 1948, vol. 59, no. 3, pp. 419–422.

The method consists in establishing an upper as well as a lower limit for the solution sought and the application of an iteration scheme similar to Picard's to narrow the "fork" between the two bounds.

(1) *Equations of the first order.* Let $y' = f(x,y)$, in which f and f_y are continuous in D, containing the point $M(x_0,y_0)$. Introduce upper bounds $v(x)$ and the lower bounds $u(x)$ of the solution:

$$v(x) > v_1(x) > \ldots > v_n(x) > \ldots > y(x),$$

$$u(x) < u_1(x) < \ldots < u_n(x) < \ldots < y(x),$$

such that $v' - f(x, y) > 0$, $u' - f(x, y) < 0$ for the interval $x_0 < x < x_1$; let $v(x_0) = u(x_0) = y_0$. Moreover, let $f_y > 0$ in the region D limited by the curves $y = v(x)$, $y = u(x)$ and the lines $x = x_0$, $x = x_1$. The iteration is carried out by means of $v_n(x) = y_0 + {}_{x_0}\int^x f(x, v_{n-1})dx$, $u_n(x) = y_0 + {}_{x_0}\int^x f(x, u_{n-1})dx$; it is proved that for $n \to \infty$ $\lim |v_n(x) - u_n(x)| = 0$ for $x_0 < x < x_1$.

(2) *Equations of higher order.* Let (*) $y'' = f(x, y, y')$, $f, f_y, f_{y'}$ being continuous in D, containing the point $M(x_0, y_0)$. Moreover, $f_y > 0$, $f_y' > 0$ in a finite interval (A, B). Call $y(x_0) = y_0$; $y'(x_0) = y_0'$ and the solution of (*) $y = y(x)$. Introduce $y = v(x)$ and $y = u(x)$ which for $(x_0, x)\epsilon D$ satisfy $v'' - f(x, v, v') > 0$; $u'' - f(x, u, u') < 0$. Call $v(x_0) = u(x_0) = y_0$, $v'(x_0) = u'(x_0) = y_0'$, $(v'(x))_{\max} = B$; $(u'(x))_{\min} = A$; then $v(x) > y(x)$; $u(x) < y(x)$. Calling $r_{n-1}(t) = v''_{n-1}(y) - f(t, v_{n-1}, v'_{n-1}) > 0$, $s_{n-1}(t) = u''_{n-1}(t) - f(t, u_{n-1}, u'_{n-1}) > 0$, the iteration formulas

$$v_n(x) = v_{n-1}(x) - {}_{x_0}\int^x (x - t)r_{n-1}(t)dt,$$

$$u_n(x) = u_{n-1}(x) - {}_{x_0}\int^x (x - t)s_{n-1}(t)dt,$$

lead to the correct solution. The method can be extended to $y^{(n)} = f(x, y, y', y'', \ldots, y^{(n-1)})$.

Courtesy of Mathematical Reviews M. Daniloff, USA

1479. H. C. Hamaker, "Random sampling frequencies; an implement for rapidly constructing large-size artificial samples" (in English), *Proc. kon. Ned. Akad. Wet.*, Apr. 1949, vol. 52, pp. 432–439.

The author presents a method whereby tables of random-sampling numbers may be used to construct a set of large-size artificial samples from which the standard error of any statistics computed from them may be rapidly estimated. The method consists of using the array frequencies as a lottery, and constructing a table of random-sampling frequencies based on the frequency of the array frequencies. Advantages of the method are that involved mathematical arguments are avoided, and it can be applied to cases not yielding to mathematical treatment.

H. R. Neifert, USA

1480. B. Saravanos, "The statistical analysis of experimental data," *Aircr. Engng.*, Mar. 1949, vol. 21, pp. 64–70 and 75.

The theory which underlies the construction and use of probability graph paper is briefly given. While originally the application of probability graph paper was limited to normal or Gaussian frequencies distribution, the method is now extended, by the introduction of new ordinates, to nonnormal distribution. Details of the method are given by means of two examples of unimodal skew-frequency distribution, one positive and the other negative.

Margot Herbeck, Germany

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1560, 1561)

1481. E. Caianiello, "On the impulsive motion of an holonomic system in the presence of simultaneous unilateral restraints" (in Italian), *R. C. Accad. Lincei*, June 1948, ser. 8, vol. 4, sem. 1, pp. 706–714.

This paper deals with sudden velocity changes caused in a holonomic system by smooth unilateral restraints when these restraints are, in the representative configuration space V_n, mutually orthogonal. It is shown that for any number r of constraints, the component of the velocity along the variety V_{n-r}, the intersection of the r constraining hypersurfaces, retains the same value, while the component along the variety V_r normal to V_{n-r} in V_n, changes sign. This happens also when the constraints have different coefficients of elasticity.

Carlo Cattaneo, Italy

1482. Georges Reeb, "On periodic motions of certain mechanical systems" (in French), *C. R. Acad. Sci. Paris*, Dec. 20, 1948, vol. 227, pp. 1331–1332.

Let V_n be the configuration space of a holonomic dynamical system subject to constraints independent of time t, to forces derived from a potential U and to periodic forces of period λ which dissipate energy, for sufficiently large velocities. It is assumed that V_n is a compact Riemannian manifold; the space of tangent vectors to V_n of norm not greater than h is denoted by W_h^*. It is then shown that the transformation T_λ which maps the point P_t of a trajectory on the point $P_{t+\lambda}$, can be interpreted as a continuous map of W_h^* into itself, for h sufficiently large, and has an algebraic number of fixed points equal to the characteristic χ of V_n. Hence if $\chi \neq 0$, the system admits periodic orbits.

Courtesy of Mathematical Reviews W. Kaplan, USA

1483. Don Mittleman, "The union of trajectorial series of lineal elements generated by the plane motion of a rigid body," *Trans. Amer. math. Soc.*, Nov. 1948, vol. 64, pp. 498–518.

This paper deals with the plane motion of an idealized system called an element-particle which moves freely under the action of any force which depends solely on the position of the body. A lineal element generates a trajectorial series, and as subsets there exist trajectorial unions whose elements coincide in direction with the tangents to the base curve of the series. General equations for the unions of the trajectorial series are developed and from these the author proves a number of theorems regarding the geometrical character of the unions. Dana Young, USA

1484. W. E. Campbell and E. A. Thurber, "Studies in boundary friction—II. Influence of adsorbed moisture films on coefficient of static friction between lubricated surfaces," *Trans. Amer. Soc. mech. Engrs.*, May 1948, vol. 70, pp. 401–408.

The authors have carried out careful measurements of the static friction between surfaces of steel, brass, silver, nickel and glass. The surfaces were maintained in an atmosphere of dry air and the effect of adsorbed moisture investigated. In general, it is found that for clean dry surfaces the friction is lower than for surfaces exposed to a moist atmosphere. Thus for steel surfaces, $\mu_{\text{dry}} = 0.8$, and $\mu_{\text{moist}} > 1$; while for silver sliding on nickel, $\mu_{\text{dry}} = 0.4$ and $\mu_{\text{moist}} > 2$. In the presence of lubricant films similar effects are observed. For example, for steel surfaces lubricated with a highly refined paraffin-base oil, the coefficient of friction for dry surfaces is $\mu = 0.35$, and for moist surfaces $\mu = 0.6$. The effect is most pronounced on glass.

It is suggested that these results support the view that friction is due to molecular forces acting across the interface. The lubricant molecules are more weakly bonded and less strongly oriented on the adsorbed water surface, so that the surfaces approach one another more closely than when the lubricant film is adsorbed directly onto the dry surface. According to this view, the increase in friction for lubricated moist surfaces is due to the additional force required to separate the increased number of metal bonds. (This would not explain the increase in friction for unlubricated moist surfaces.) The authors point out that these effects are complicated for lubricants containing fatty acids, since, with metal surfaces, metallic soaps may be formed between the sliding surfaces. D. Tabor, England

1485. Clifford Truesdell, "Generalisation of the Cauchy formula and of the Helmholtz theorems for the motion of any continuous medium" (in French), *C. R. Acad. Sci. Paris*, Oct. 18, 1948, vol. 227, pp. 757–759.

The author studies the change of vorticity in a fluid of the most general type, the argument being purely kinematical. The basic idea is to split the change of the vorticity vector (as we follow a fluid particle for finite time) into two parts, one of which is due to convection and the other to diffusion. The diffusion term disappears if the motion is such that the circulations in all closed circuits are conserved. In general, the convection depends only on the relative displacements of the particles at the final instant, but the diffusion depends essentially on the history of the motion.

Courtesy of Mathematical Reviews J. L. Synge, Ireland

Gyroscopics, Governors, Servos

1486. B. R. Parkinson, "Governors and governing," Walter King, London, 1947. Cloth, 5.2 × 8.2 in., 203 pp., 128 fig.

The principal types of governors and their mechanisms are briefly described. A set of formulas and tables is attached at the end of the book. Ed.

1487. J. N. Roitenberg, "Self-excited oscillations of gyroscopic stabilizers" (in Russian), *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*), Mar.-Apr. 1947, vol. 11, pp. 271–280.

The author's summary states that the paper treats the motion of a gyroscopic stabilizer connected with a motor whose function is to overcome the action of external forces on the object to be stabilized. The current feeding the motor is regulated by an amplifier. The author considers the case when the characteristic of the voltage fed into the amplifier is determined by the function $S \cdot \sin B$, where B is the angle of rotation of the gyroscope about the axis of its box. The periodic solution of the equations of motion is obtained, and it is shown that the solution is stable. The gyroscopic stabilizer in this case, therefore, performs self-excited oscillations. A numerical example is worked out. John M. Kopper, USA

Vibrations, Balancing

(See also Revs. 1482, 1487)

1488. Giuseppe Colombo, "On frequencies and on the damping of the oscillations of a sphere vibrating radially in a liquid" (in Italian), *R. C. Semin. Mat. Univ. Padova*, 1948, vol. 17, pp. 107–114.

In this paper the author analyzes the roots of the characteristic equation, $\tanh x(1 + px^2)(x - \tanh x)^{-1} = -mx^2(1 + nx)^{-1}$, which he obtained in a previous paper in connection with the problem of the motion of a sphere vibrating radially in a fluid medium. The first member of the equation is expanded into an infinite product, and the result of the analysis of the roots is that the oscillations of the sphere are damped. Furthermore, the author discusses two cases, one when the parameter $\mu = \alpha\beta$ is very small, and the other when μ is very large. Here α represents

the ratio of the density of the fluid to that of the sphere, and β the ratio of the velocity of the waves in the fluid to the velocity of the waves longitudinal in the sphere. In the first case, the frequencies of oscillations are smaller than for the case when the sphere vibrates freely in a vacuum, and the damping increases with the frequency. For the second case the frequency still decreases with increasing μ and vanishes for $\mu \to \infty$. Finally for values of μ sufficiently large, the damping diminishes as μ increases. The problem is still open for investigation in the case when μ approaches zero and infinity. The paper contains a number of misprints and omissions in some formulas.

N. Chako, USA

1489. Henri Pailloux, "On some oscillation problems" (in French), *C. R. Acad. Sci. Paris*, Dec. 8, 1948, vol. 227, pp. 1208–1210.

Considering the oscillation of a hanging cord, the author indicates the conditions under which the solution to a certain boundary-value problem exists. A power series technique is used and the convergence questions are omitted. A second problem deals with a dissipative oscillating system. For a very special case, the problem is reduced to that of solving some algebraic equations.

George Carrier, USA

Wave Motion, Impact

(See also Revs. 1511, 1520, 1521)

1490. T. Kanazawa, "On elastic shock waves in a conical bar" (in Japanese), *J. Soc. appl. Mech. Japan*, Sept. 1948, vol. 1, pp. 14–21.

Taking the axis of a conical bar as the x-axis and the vertex as the origin $x = 0$, the author considers the propagation of elastic waves in the bar with the initial conditions: (a) $y = \varphi(x)$, $\partial y/\partial t = 0$; (b) $y = 0$, $\partial y/\partial t = \psi(x)$; (c) $y = \varphi(x)$, $\partial y/\partial t = \psi(x)$, where y is the amplitude of the wave and φ, ψ are functions of the form: $A_0c^2/(c^2 + x^2)$ or $B \exp(-x/c)$, $c > 0$. In particular, the author studies the damping properties which are absent in the case of a uniform straight bar and are peculiar to a conical bar.

T. Mogami, Japan

Elasticity Theory

(See also Revs. 1488, 1550)

1491. R. S. Rivlin, "Large elastic deformations of isotropic materials, Parts I, II, III, and IV," *Phil. Trans. roy. Soc. Lond. Ser. A*, 1948, vol. 240: no. 822, Jan. 13, pp. 459–508; no. 823, Feb. 24, pp. 509–525; no. 835, Oct. 5, vol. 241, pp. 379–397.

These papers concern the general theory of elasticity, particularly for incompressible and isotropic materials. By elasticity we mean a theory based upon a strain energy W, which is a function only of the finite strain from a natural state. Unfortunately the author's analysis is encumbered and obscured by extended and often ill-chosen notations. The present review presents the results in terms of matrix and tensorial notations, which in the theory of elasticity more than in any other field of classical mechanics are almost a necessity not only for brevity but also for perspicuity.

Let C and c be Cauchy's deformation tensors, defined by $ds^2 = C_{\alpha\beta}dX^\alpha dX^\beta$, $ds_0^2 = c_{ij}dx^i dx^j$, where the X^α are the (Lagrangian) coordinates in the undeformed state, with element of arc ds_0^2, while the x^i are (Eulerian) coordinates in the deformed state with element of arc ds^2. The Green-St. Venant and Almansi-Hamel strain tensors E and e are given by $C = I + 2E$, $c = I - 2e$. In part I the author defines the "neo-Hookean" material as one having a strain energy W of the form αI_E, where the notation I_b means the first invariant of b. Equivalently, $W = \alpha(I_{c^{-1}} - 3)$, where c^{-1} is the inverse of c. For an incompressible material the stress-strain relations then are $t^i{}_j = p\delta^i{}_j - \alpha(c^{-1})^i{}_j$, where t is the ordinary (Cauchy) stress tensor and p is a hydrostatic pressure.

(Reviewer's note: Following a tentative of St. Venant, Kirchhoff in *Akad. Wiss. Wien*, 1852, vol. 9, pp. 762–773 gave a theory from which the author's is easily deduced Expanding the strain energy in a series, $W = \alpha I_E + (\lambda + 2\mu)I_E{}^2/2 - 2\mu II_E + \ldots$, Kirchhoff puts $\alpha = 0$ so as to exclude initial stress; the author's theory retains α but neglects the terms in λ and μ, and adds the requirement of incompressibility. In terms of the Lagrangian stress T used by Kirchhoff, $T^\alpha{}_\beta \equiv JX^\alpha{}_{,i}X_\beta{}^{,j}t^i{}_j$, where J is the Jacobian det $x^i{}_{,\alpha}$ and commas denote partial differentiation, the author's stress-strain relations are $T^\alpha{}_\beta = pC^\alpha{}_\beta + \alpha\delta^\alpha{}_\beta$.

As far as the general theory is concerned, the author's contribution is to show that the requirement of incompressibility leads to the possibility of a simple nonlinear theory. The stress-strain curve for simple extension is $t = \alpha(\lambda^2 - \lambda^{-1})$, where λ is the extension ratio. These results have been deduced from a structure theory for high polymers by Guth and James [*Ind. Eng. Chem.*, 1941, vol. 33, pp. 624–629] and several others. The author proves that corresponding to a given state of stress there exists a unique p giving rise to real extensions. (Reviewer's note: In *Proc. Camb.*, 1948, vol. 44, pp. 595–597, the author gives a shorter proof of this same result for the more general Mooney material mentioned below. The remainder of the material in part I is well known, e.g., E. and F. Cosserat, *Ann. Toulouse*, 1896, vol. 10, pp. I1–I116; and E. Hellinger, *Enz. Math. Wiss.*, 1914, vol. 4, part 4, pp. 602–694.)

Part II considers pure, homogeneous strain of a cube of incompressible, neo-Hookean material under the action of three pairs of equal and oppositely directed forces f_1, f_2, f_3 applied normally to the parallel faces. If one or more of the f's be negative, or if all are positive and $f_1f_2f_3 < \alpha^3$, then the equilibrium state is not necessarily unique. In the former case the equilibrium is stable, but in the latter case there are eight different types of equilibrium states, four being unstable and one stable. The author analyzes further possibilities.

In part III the author laboriously transforms the principal equations to cylindrical polar coordinates. He shows that simple torsion of a circular cylinder can be produced by end stresses only, but that these must have normal as well as tangential components. He gives solutions also for the combined torsion and extension of a cylinder, and for the torsion of a hollow cylinder.

In part IV the author takes up the general theory again. He establishes the relations $I_e = II_C/III_C$, $II_e = I_C/III_C$, $III_e = 1/III_C$ connecting the principal strain invariants, noting also that C and c^{-1} have the same invariants. (Reviewer's note: An equivalent result for e and E was given by Murnaghan, *Amer. J. Math.*, 1937, vol. 59, pp. 235–260). He then establishes the simplifications introduced into the general stress-strain relations when the medium is isotropic, obtaining $Jt_j{}^i = A\delta_j{}^i + Bc_j{}^i + C(c^{-1})_j{}^i$, where $A \equiv 2\, III_C\partial W/\partial III_C + 2II_C\partial W/\partial II_C$, $B \equiv -2III_C\partial W/\partial II_C$, $C \equiv 2\partial W/\partial I_C$. (Reviewer's note: This result is due to Finger, *Akad. Wiss. Wien Sitzb.*, 1894, ser. IIa, vol. 103, p. 1073.) For an incompressible material, $III_C = J = 1$, and A becomes simply an arbitrary pressure. (Reviewer's note: General stress-strain relations for incompressible elastic materials were derived by Poincaré, *Théorie Mathématique de la Lumière*, Paris, 1889, see sect. 152, and *Leçons sur la théorie de l'Élasticité*, Paris, 1892, see sect. 33, using the method employed by Lagrange, *Misc. Taurinensia 2²*, 1760–1761, pp. 196–298; *Oeuvres 1*,

pp. 365–468, see chap. XL, in a special case.) The author makes the important observation that in any particular experiment, especially the simple ones generally employed, the strain energy assumes a simplified form, and that consequently data from this experiment yield information only about a portion of the strain-energy function and, no matter what the accuracy of the experiment, are incapable of determining this function in general, and hence are incapable of yielding information sufficient to predict the response of the material in most other situations.

In part C of part IV the author gives his most valuable contribution, exact solutions of three problems valid for *any* form of the strain energy. He finds the forces necessary to produce a simple shearing displacement in a parallelopiped, whether compressible or incompressible; tangential forces alone are insufficient, although it is possible (as in the infinitesimal theory) for the two faces perpendicular to the axis of shear to remain unstressed. The author finds the forces which must be applied to the ends of a right circular cylinder in order to produce a pure torsion, specializing his general result to the case of a Mooney material [M. Mooney, *J. appl. Phys.*, 1940, vol. 11, pp. 582–590], for which $W = \alpha(I_{c-1} - 3) + \beta(I_c - 3)$. (Reviewer's note: The existence and magnitude of the normal end tractions thus predicted are checked by the author in experiments on rubber, *J. appl. Phys.*, 1947, vol. 18, pp. 444–449, 837). (See following review.) C. A. Truesdell, USA

1492. R. S. Rivlin, "Large elastic deformations of isotropic materials. V. The problem of flexure," *Proc. roy. Soc. Lond. Ser. A*, Feb. 3, 1949, vol. 195, pp. 463–473.

(See preceding review.) For a general strain-energy function, the author finds the surface tractions necessary to produce a state of circular flexure in an incompressible rectangular parallelopiped. There are several possibilities; it is always possible for the cylindrical faces to be unstressed and for the end tractions to reduce to pure couples, and in this case the neutral axis is given by the classical formula. The author specializes his results to apply to a Mooney material, and also obtains approximations valid for small curvature. C. A. Truesdell, USA

Experimental Stress Analysis

(See also Rev. 1511)

1493. B. R. Lee, R. Meadows, Jr., and W. F. Taylor, "The photoelastic laboratory at the Newport News Shipbuilding and Dry Dock Company," *Proc. Soc. exp. Stress Anal.*, 1948, vol. 6, no. 1, pp. 83–110.

The authors describe a new laboratory in which they have assembled most of the best features of various laboratories of their acquaintance. Much information is given concerning design and techniques for a photoelastic polariscope and auxiliary equipment, with the advantages and disadvantages of alternate systems. The article is of particular interest to one starting such a laboratory. William N. Findley, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 1492, 1501, 1503, 1519, 1545)

1494. G. G. McDonald, "The graphics of pulsating stresses," *J. Instn. Engrs. Austral.*, Dec. 1948, vol. 20, pp. 195–196.

The author discusses the case of a uniform cylindrical shaft subjected to a pulsating bending moment $M \pm m$ and a pulsating twisting moment $T \pm t$. All possible combinations of fluctuating bending and shear stresses are treated, and a method for the graphical representation of the various failure hypotheses is given. The general design case is then discussed, taking into account the various strength reduction factors due to stress raisers and marginal factors of safety.

The most general expression for the diameter D of a hollow shaft, using the empirical Soderberg straight line hypothesis and the shear strain energy theory of failure, is given as

$$D^6 = \frac{16}{\pi(1 - h^4)} [4(k_M\phi_M M/Y + k_m\phi_m m/N)^2 + 3(k_T\phi_T T/Y + k_b\phi_b t/N)^2]$$

where: h is the core diameter/D, k_M, k_T, k_m, k_t are strength-reduction factors applied to the steady and fluctuating components respectively, ϕ_M, ϕ_T, ϕ_m, ϕ_t are the corresponding marginal factors of safety, Y is the yield strength, and N the endurance limit for reversed bending.

The paper is very concise. The author merely states the results obtained by using certain hypotheses and failure theories, without recommending any of them. Nicholas Sag, Australia

Plates, Disks, Shells, Membranes

(See also Rev. 1503)

1495. W. J. Kommers and C. B. Norris, "Stiffness of flat panels of sandwich construction subjected to uniformly distributed loads normal to their surfaces—simply supported edges," *For. Prod. Lab. Rep.*, no. 1583-A, Oct. 1948, 10 pp.

This presents a supplementary report of experiments to verify previously published theoretical formulas [H. W. March, *For. Prod. Lab. Rep.*, no. 1583, May 1948 (eqs. 89, 90); see Rev. 25, Jan. 1949] on the stiffness of flat panels of sandwich construction. The formulas define the center deflections in flat panels with simply supported edges and a uniformly distributed load, including the effect of shear deformation in the low density core materials. Fifty-seven tests on 15 panels of sandwich construction were made, using various facing and core materials. The test deflections agreed reasonably well with the formulas.

Joseph Marin, USA

Buckling Problems

(See also Revs. 1501, 1503)

1496. Evan H. Schuette, "Column curves for magnesium-alloy sheet," *J. aero. Sci.*, May 1949, vol. 16, pp. 301–305 and 310.

Results are presented for compression tests of specimens cut from sheets of FS-1h, FS-1a and Ma magnesium-alloy. Column curves of the parabolic type with horizontal cut-offs at the compressive yield strength are shown to fit the data with reasonable accuracy. John E. Goldberg, USA

1497. W. Schibler, "Buckling of a two-hinged arch in its own plane, including the effect of the upper structure" (in German), *Schweiz. Bauztg.*, Aug. 28, 1948, vol. 66, pp. 482–485.

Buckling of a two-hinged arch in its own plane under end thrust is studied for arches with different types of upper structure. The critical end thrust for any given system is found to depend on the rise (camber), the height of the upper structure above the arch axis, and the stiffness of the upper structure.

Conrad C. Wan, USA

Joints and Joining Methods

(See Revs. 1499, 1514)

Structures

(See also Rev. 1546)

1498. Netter, "The pre-stressed concrete runway at the Orly airport" (in French), *Bâtim. Trav. publics*, Jan. 1948, no. 5, pp. 6–18.

After some remarks on the reasons for choosing prestressed concrete, a description is given of the runway, which is 420 m long, 60 m wide, and is designed for concentrated service loads of 85 tons. The fabrication and prestressing procedures and the effect of the cable loads, temperature changes and temperature differences between upper and lower surface are discussed. Some brief remarks are made on stability under initial compression. Static and repeated load tests on an experimental panel (14 m × 12.5 m) and on the actual runway are described, and the results are interpreted and compared with experience gained with ordinary concrete runways. F. J. Plantema, Holland

1499. Clifford D. Williams and Ernest C. Harris, "Structural design in metals," The Ronald Press Co., New York, 1949. Cloth, 6.5 × 9.25 in., 596 pp., 285 figs., $6.50.

This new book is concerned chiefly with the practices used in the selection and detail design of the various members and connections which comprise a building or bridge structure. With the exception of a section on the "rigid-frame bridge," no effort is made to present information on analysis. While intended primarily as a text for engineering students, the book may prove helpful to mechanologists who, during the course of their training, have by-passed the study of design procedures but now wish to familiarize themselves with the common and acceptable methods used in the detail design of bridges and buildings. Ed.

1500. E. Melan, "A convergence proof of Cross' approximation method for calculation of statically indeterminate systems" (in German), *Anz. Akad. Wiss. Wien*, 1947, vol. 84, no. 1–15, pp. 15–17.

The Hardy Cross moment-distribution procedure is expressed in terms of the angular rotation of the joints, and a proof is given for its convergence in this form. Dana Young, USA

1501. L. Ross Levin and Charles W. Sandlin, Jr., "Strength analysis of stiffened thick beam webs," *Nat. adv. Comm. Aero. tech. Note*, no. 1820, Mar. 1949, pp. 1–22.

The report presents some modifications of semiempirical methods which were previously developed by the National Advisory Committee for Aeronautics for predicting ultimate static loads of plate-girder beams of the wing-spar type. The earlier formulas were found to be inaccurate for cases in which the ultimate shear loads of the beams do not greatly exceed the web buckling loads.

This report treats cases for which the ratio of the ultimate load to the web buckling load is less than 2.5. Edge-restraint factors for the computation of the shear buckling stress of a web panel are discussed. Formulas are given for calculating the load to cause web rupture, and the load to cause forced crippling of web stiffeners. The latter type of failure occurs if the stiffeners are not rigid enough to suppress diagonal wrinkles in buckled web panels. The formulas that are presented are supported by experimental results from a number of test beams.
H. L. Langhaar, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1491, 1492, 1511, 1513, 1519, 1547)

1502. Louis Gold, Lawrence Malvern and R. C. Meacham, "Single crystal plasticity. A survey," *Brown Univ. Rep.* (Contract N7onr-358 T.O.1), no. A11-S3, 1948: Part I, Sept., 170 pp.; Part II, Nov., 149 pp.; Part III, Aug., 156 pp.

Part I ("Some essential background to the understanding of the mechanical behavior of bulk materials," by Louis Gold) consists of four chapters, dealing with crystal structure and X-ray analysis, X-ray techniques, crystal growth, and crystal perfection. The first two chapters have the character of university lecture notes; the third professes to give the theory and techniques of crystal growth, but the important advances of the theory during the last 20 years (Kossel, Stranski, Volmer) are not mentioned, and some of the most useful methods of preparing single crystals (such as that of Andrade) are omitted, while others of no practical significance (such as the Kapitza hot-plate method) are described. Similarly, the treatment of crystal perfection frequently corresponds to the state of knowledge of 15 years ago (Renninger's discovery of perfect NaCl is not mentioned; NaCl is said to give, generally, "poor agreement" with the theory of diffraction of the perfect crystal).

Part II ("Experimental studies of the plastic deformation of single crystals," by Lawrence Malvern) represents probably the most up-to-date review available of experimental work on the plasticity of single crystals, including a treatment of the plastic properties of polycrystalline aggregates on the basis of the behavior of single crystals. Although a report of the limited size of the present one cannot be complete or even balanced, this report contains a considerable amount of valuable information which is not obtainable in any other single book. The titles of its six chapters are: Homogeneous deformation of single crystals—the influence of temperature; Dynamic testing—the influence of strain rate and of crystal imperfection and impurities; Experimental studies of the mechanism of slip; Inhomogeneous deformation of single crystals; Generalization from single crystal results to polycrystalline behavior; Related experimental studies—conclusion.

In view of the prevailing uncertainty about many of the fundamental questions of crystal plasticity, the task of part III ("Theories of plastic deformation of single crystals," by R. C. Meacham) must have been the most difficult one. While there is no clear physical picture of the mechanism of plastic deformation (e.g., of strain hardening, thermal recovery, recrystallization, time effects of slip, etc.), the author of this volume has given a really clear account of the attempts which have been made to provide such pictures. The most solid achievement of the theory is the realization that the typical injury of the crystal lattice arising in the course of slip is the dislocation, and that the stresses produced by dislocations can be treated quantitatively, by methods developed by Volterra, Timpe, Koehler, and others. In the center of the present report, accordingly, is the theory of dislocations and its applications to various problems of plastic deformation. E. Orowan, England

1503. A. A. Ilyushin, "Theory of elastoplastic deformations and its applications" (in Russian), *Bull. Acad. Sci. USSR Ser. tech. Sci.* (*Izv. Akad. Nauk SSSR Ser. tekh. Nauk*), June 1948, no. 6, pp. 769–788.

The introductory part of the paper contains the presentation of a new generalized theory of the elastoplastic state of stress and deformation. The basic law of this theory refers to the mechanical conditions at a point, and it relates the deviator stresses

and strains, past, present and future, in the form of a linear equation of the components of stress and strain-deviator tensors and their time derivatives and integrals.

Further attention is given to a special case of the general theory, termed "simple loading," in which the stress-deviator tensor at a point, and also the strain tensor, vary with time in such a way that they remain similar to themselves. The postulate of simple loading specifies the conditions under which this state of stress is materialized.

The greater part of the paper is devoted to a brief review of a large number of problems of plasticity with some of the results and hints about the methods of solution. The problems discussed include: bending of a rectangular beam; stability of a rod; torsion of a circular shaft; hollow spheres and tubes under internal and external pressures; several cases of bending and stability of plates and shells; pressing of punches; and a brief reference to two dynamic problems.

Although interesting as presenting a wider view on the problem of plasticity, the work should not be passed without criticism. No attempt has been made to apply to the actual problems the wider scope of conditions visualized in the general theory. No example of the author's simple loading is given, and such a condition appears very problematical in actual practice. The review of the problems of plasticity discussed is overcondensed.

A. Hrennikoff, Canada

(Editor's Note: A twenty-five-page translation of this paper has been made by Dr. Hrennikoff, and the editor can supply photostats at the usual rate.)

1504. Takesi Sugeno, "Quenching stresses of steel" (in Japanese), *Trans. Soc. mech. Engrs. Japan*, Jan. 1947, vol. 13, no. 43, pp. 1–13.

Carbon-steel test pieces of length 123 mm and diameter 44 mm were quenched in various conditions, and residual stresses were measured by Sachs's method [*Z. Metallk.*, 1927, vol. 19, p. 352]. In accordance with H. Bühler's research on Fe-Ni alloy [*Arch. Eisenhüttenw.*, 1933, vol. 6, p. 283], residual stresses due to transition are shown to be in the opposite direction from those due to thermal expansion.

S. Moriguti, Japan

1505. K. M. Entwistle, "The damping capacity of metals in transverse vibration," *J. Inst. Metals*, Oct. 1948, vol. 16, part 2, pp. 81–96.

The paper describes a method of measuring damping capacities at very low stresses in specimens of uniform cross section vibrating in the fundamental, transverse, "free-free" mode.

The damping capacities of several aluminum alloys and beryllium copper were studied, including studies of the effect of solution treating and aging. It was found that elevated temperature precipitation in alloys fully aged at room temperature produced marked reductions in damping capacity. The author reports higher damping values for some of the aluminum alloys than previously reported by Frommer and Murray [*J. Inst. Metals*, 1944, vol. 70, p. 1). He ascribes this discrepancy to the presence of thermal currents in his specimens as a result of the use of magnetically-induced eddy currents in his method of excitation.

Morton B. Millenson, USA

1506. K. M. Entwistle, "The effect of grain-size on the damping capacity of alpha brass," *J. Inst. Metals*, Oct. 1948, vol. 16, part 2, pp. 97–106.

The effect of grain size on the damping capacity of alpha brass has been measured in both torsional and transverse vibration. These tests are in close agreement with predictions by Zener as to the contribution to damping capacity by intercrystalline thermal currents. Similar results had previously been obtained by Randall, Rose and Zener for longitudinal vibrations [*Phys. Rev.*, 1939, vol. 56, p. 343].

Morton B. Millenson, USA

Failure, Mechanics of Solid State

(See also Revs. 1494, 1511, 1515)

1507. Toshio Nishihara and Atsuro Kobayashi, "New theory of fatigue of metals and its application" (in Japanese), *Trans. Soc. mech. Engrs. Japan*, May 1947, vol. 13, no. 44, pp. 56–67.

The authors have developed a theory of fatigue [*J. Soc. mech. Engrs. Japan*, Dec. 1945, vol. 48, p. 113] leading to the relation $H^{mpN} = \sigma^{1+m}/(\sigma^{1+m} - \sigma_D{}^{1+m})$, where N denotes the number of repetition of stress σ up to failure, σ_D the endurance limit, H the hardening factor (defined by the authors), m a constant such that σ^m is proportional to the permanent strain, and p the ratio of the number of repetitions of load up to failure to the number of repetitions until a crack is generated in the weakest crystal grain.

In the present paper, developing the theory further, the authors propose a method for rapid determination of the endurance limit from fatigue test data, and calculate the fatigue strength of metals under nonsinusoidal load. Experiments check the calculations to a considerable extent.

S. Moriguti, Japan

1508. H. Brandenberger, "Relation between static and fatigue strength" (in German), *Schweiz. Bauztg.*, Feb. 28, 1948, vol. 66, pp. 121–123.

This paper discusses a theoretical relationship, developed in the author's previous papers, between "proportional limit," "yield point," and fatigue strength or endurance limit for various combinations of maximum and minimum stresses. The reviewer notes, however, that test results on materials without stress concentration, of which the author is apparently unaware, do not bear out his contention.

N. M. Newmark, USA

1509. F. K. Th. van Iterson, "Brittle rupture of plastic material" (in English), *Proc. kon. Ned. Akad. Wet.*, Mar. 1947, vol. 50, pp. 246–251.

In this brief communication the author discusses the possibility of the development of triaxial stress distributions in various structures. He uses as one example an I-beam with a residual triaxial stress distribution resulting from differential contraction and plastic flow occurring during cooling from the rolling temperature, and shows how a load on such a structure can result in a brittle failure even in a very ductile mild steel. The theory developed by Mariotte and Poncelet, based on a maximum possible elastic strain, is used in the presentation.

Morton B. Millenson, USA

Design Factors, Meaning of Material Tests

(See Revs. 1494, 1508, 1511, 1516, 1532)

Material Test Techniques

(See also Revs. 1505, 1506, 1513)

1510. J. H. Teeple, "Methods of testing," *Elastomers and plastomers, Vol. 3*, Elsevier Publ. Co., Inc., 1948, pp. 11–68.

This section nominally treats the methods of testing plastics and elastomers, but the discussion is directed primarily to the

former. The emphasis is placed upon testing machines and methods of conducting tests. Some test results are included, but these are intended primarily to illustrate the type of results obtainable, or to show the correlation between different test results. Approximately 50 per cent of the chapter is devoted to the determination of the usual mechanical properties of rigid plastics. The remainder of the chapter discusses casting and molding properties; conditions which affect test results; thermal properties; chemical properties, (resistance to reagents, water absorption, vapor permeability, aging, and dimensional changes); and electrical tests. An extensive bibliography is included.

Charles E. Crede, USA

1511. Kurt Fink, "The experimental investigation of the onset of flow of mild steel under impact" (in German), *Arch. Eisenhüttenw.*, 1948, vol. 19, pp. 153–160.

The author's summary states that by means of a tensile-impact and a compressive-impact device the force-time relation under impact loading of mild steel was determined with the use of strip-resistance strain gages, and analyzed with the aid of the theory of propagation of elastic waves in solid bodies. Because of the complicated force-time relationship associated with the usual impact-test methods, a test apparatus was developed which produced clearly defined loading conditions and assignable velocities of loading. As the first result of this investigation, for mild steel an increase in the upper yield point of more than 100 per cent of the static value was found. The upper yield point, moreover, exceeded considerably the "dynamic tensile strength" corresponding to the velocity of deformation in the impact test. The relative increase in the yield point for the same velocity of loading decreased with increasing carbon content.

Wm. R. Osgood, USA

1512. Nobusuke Enomoto, "Study on fatigue and internal friction of metals" (in Japanese), *Trans. Soc. mech. Engrs. Japan*, Jan. 1947, vol. 13, no. 43, pp. 21–32.

Fatigue tests of annealed low-carbon steel were carried out with various stress amplitudes and mean stresses. The damping factor, permanent set, and temperature rise were observed, and their relation to fatigue is discussed. S. Moriguti, Japan

Mechanical Properties of Specific Materials

(See also Revs. 1491, 1492, 1495, 1502, 1505, 1506, 1510)

1513. W. N. Findley, C. H. Adams, and W. J. Worley, "The effect of temperature on the creep of two laminated plastics as interpreted by the hyperbolic-sine law and activation energy theory," *Proc. Amer. Soc. Test. Mat.*, 1948, vol. 48, pp. 1217–1239.

Tensile creep tests of a canvas laminate and a rayon laminate were performed at temperatures of 42.5, 77 and 128.4 F, with a relative humidity of 50 per cent. Complete description of the materials, apparatus, and testing procedure is given, with the results shown in curves and tables. The canvas laminate, molded at 180 psi with a phenol formaldehyde resin, was inferior in creep resistance to the rayon laminate molded at 1100 psi with a phenolic resin; for the same total creep at 800 hr, the canvas laminate withstood roughly half the stress.

Test results are compared with the hyperbolic-sine law for the relation between stress and creep at 800 hr. Reasonably good agreement was found at the three temperatures for the canvas laminate and at 77 F for the rayon laminate, and the constants for these cases are derived. Creep rates of the canvas laminate at 800 hr agree fairly well with the activation energy theory, and the quantities involved are of the same order of magnitude as for some metals. Henry A. Lepper, Jr., USA

1514. W. I. Pumphrey and P. H. Jennings, "High-temperature tensile properties of cast aluminum-silicon alloys and their constitutional significance," *J. Inst. Metals*, Dec. 1948, vol. 75, pp. 203–233.

To study the tendency for cracking during welding or casting, the authors determined the high temperature tensile strength and ductility of several aluminum-silicon alloys. Strength vs. temperature curves were obtained for specimens cooled slightly below the liquid state and for rapidly reheated specimens machined from chill-cast alloys.

At temperatures somewhat below melting the specimens broke with a ductile type fracture, the strength gradually decreasing as the testing temperature was increased. As the melting point was approached a point was reached where a brittle type fracture was obtained. This point was associated with the effective solidus temperature. As the temperature was further increased the fracture was still of the brittle, intercrystalline type, while the strength decreased rapidly. This brittle range was correlated with cracking due to welding and casting. E. A. Davis, USA

1515. Walter R. Hibbard, Jr., "Preferred orientations in drawn and annealed 70-30-alpha brass tubes," *Trans. Amer. Inst. min. metall. Engrs.*, 1948, vol. 175, pp. 52–65.

The textures in drawn 70-30 alpha-brass tubes were found to be governed by a double texture with the [111] and [100] poles parallel to the drawing direction and a random orientation about these directions, being similar to the fibre texture of drawn wires of alpha brass. At reductions in area up to about 25 per cent the texture is partially, and at reductions of about 45 per cent fully, developed. Annealing textures are partly randomized variations of the drawing texture. Hard drawn tubes did not show cracking when subjected to standard mercurous nitrate tests for 50 hr, although the large deformations should be capable of causing failure.

From this and other previous observations, some of them on single crystals, the author concludes that the insensibility towards cracking is a consequence of the preferred orientation. He puts forward the idea that in single crystals and between similarly oriented grains there exists no marked grain boundary or notch effect, which would allow a concentrated corrosion attack.

Albert Kochendörfer, Germany

1516. W. Leighton Collins, "Fatigue and static load tests of an austenitic cast iron at elevated temperatures," *Proc. Amer. Soc. Test. Mat.*, 1948, vol. 48, pp. 696–708.

Repeated load and short-time static-load tests are reported for notched and unnotched specimens machined from large plates of one heat of a commercial austenitic cast iron designed for high temperature use. No appreciable difference was observed between the static tensile strengths of specimens notched with a circumferential V-groove and unnotched specimens, at any temperature from room temperature to 1100 F.

The endurance limit for completely reversed cycles of bending stress as determined from unnotched specimens was practically the same as that for specimens containing a small transverse hole for all tests at five different temperatures ranging up to 1160 F. The endurance limits for the two types of specimens varied only slightly at any test temperature provided the net cross section was used in computing the stress in the specimens with the notch. The average static tensile strength of the austenitic cast iron de-

creased from 45,500 psi at room temperature to 30,400 psi at 700 F and dropped to 19,900 psi at 1160 F. The ratio of endurance limit to tensile strength increased from 0.37 at room temperature to 0.60 at 1160 F. T. J. Dolan, USA

1517. Werner Koster and Walter Rauscher, "Relation between the modulus of elasticity of binary alloys and their composition" (in German), *Z. Metallk.*, Apr. 1948, vol. 39, pp. 111–120.

This investigation gives a very comprehensive picture of the dependence of modulus of elasticity on the relative concentration in binary alloys. Gapless mixed-crystal series, eutectic-alloy series, and alloys with intermetallic phases were investigated. In the tests, the most important structural systems were considered in order to obtain some insight into the relation between lattice structure, type of binding, and elastic behavior.

Henri M. Schnadt, Luxemburg

1518. Fred Werren, "Fatigue of sandwich constructions for aircraft (Cellular cellulose acetate core material with aluminum or fiberglas-laminate facings, tested in shear)," *For. Prod. Lab. Rep.*, no. 1559–F, Dec. 1948, 6 pp.

The author presents data supplementary to a series of previous reports of the author on sandwich materials [*For. Prod. Lab. Rep.*, nos. 1559, A, B, C, D, E; see Rev. **1013**, Aug. 1949]. The new results are those of fatigue tests in shear of cellular cellulose-acetate core material with aluminum-alloy or fiberglas-laminate facings. The results indicate a fatigue strength, at 30 million cycles, of approximately 36 per cent of the static strength in shear, this being independent of the skin material.

Frank J. Mehringer, USA

Mechanics of Forming and Cutting

1519. R. McC. Baker, R. E. Ricksecker and W. M. Baldwin, Jr., "Development of residual stresses in strip rolling," *Trans. Amer. Inst. min. metall. Engrs.*, 1948, vol. 175, pp. 337–354.

This paper describes experimental investigations of residual stresses developed during strip rolling. The present trend toward rolling thick sections prompted a study of the effect of roll diameter, strip thickness, reduction per pass, etc., on the residual stress in the strip.

Assuming a simplified distribution of residual stress through the strip thickness, the apparent residual stress was studied, and the results obtained indicate that: (a) the residual stress is almost constant over the width of the strip, and (b) the ratio of the residual stress to the yield strength is proportional to the square of the ratio of the strip thickness to the contact length between the roll and the strip, and is unaffected by the magnitude of the reduction per pass.

These results are important in connection with fire cracking, which occurs when the residual stresses are too high and the metal is heated too quickly during annealing, and alligatoring which occurs when strips are rolled from castings; when residual stresses are high, such strips split along their midplane parallel to the direction of rolling. The authors give a critical comparison between their own and previous results.

Nicholas Sag, Australia

Hydraulics; Cavitation; Transport

(See Revs. 1520, 1534)

Incompressible Flow: Laminar; Viscous

(See also Revs. 1485, 1557)

1520. J. J. Stoker, "The formation of breakers and bores," *Commun. appl. Math.*, Jan. 1948, vol. 1, pp. 1–87.

This paper is a mathematical study of surface gravity waves in shallow water, with special emphasis on the treatment of problems concerning the change in form of water waves as they propagate into quiet water. The development of breakers on sloping beaches and the formation of "bores" in rivers due to tidal action are considered in detail.

The mathematical methods used by the author involve partial differential equation identical in form with those used in studying the unsteady flow in one dimension of a compressible gas. Large portions of the paper consist in interpretation in terms of surface-wave phenomena of rather well-known results from gas dynamics.

The analysis begins with a discussion of the propagation of pulses and depression waves into still water of constant depth. A bore or nonsteady hydraulic jump is identified with the development of a singularity in the water surface slope. The breaking of a dam and the propagation of flood waves in a river channel are treated. The formation of breakers for waves of three typical shapes is analyzed for the case of shallow water of constant depth and for uniformly sloping beaches. Numerical results are obtained for predicting the increase in amplitude of the breaker and the location of the "break point." A short discussion of the available experimental data is given, which indicates satisfactory agreement with the theory. S. A. Schaaf, USA

1521. Fritz John, "On the motion of floating bodies. I," *Commun. pure appl. Math.*, Mar. 1949, vol. 2, pp. 13–57.

The boundary-value problem associated with the motion of a rigid infinitely long cylindrical body partially immersed in an incompressible inviscid fluid is carefully formulated. The formulation is then simplified to the case of small motions (the linear theory), and then to the situation wherein the depth of the fluid is small compared to the values of curvature of the body and to the wave length of the surface waves.

The author then solves four specific problems in the linear shallow-water theory. The results obtained are: (1) the motion of the body after its release in a nonequilibrium position; (2) the motion of the fluid associated with a forced oscillation of the obstacle; (3) the reflection and transmission of waves which are incident on the fixed, partially immersed obstacle; and (4) the reflection and transmission of waves which are incident on the freely floating obstacle. The dependence of the quantities characterizing these results on the parameters of the system (for example, the damping time as a function of draught to depth ratio) are discussed and graphically illustrated. George Carrier, USA

1522. Busuke Hudimoto and Kōzi Hirose, "On the theory of wing lattice" (in Japanese), *Trans. Soc. mech. Engrs. Japan*, May 1947, vol. 13, no. 44, pp. 165–169.

In the first part of this paper, Munk's theory of thin airfoils is extended to cover the case of slightly nonuniform flow. The method used consists of determining suitable distributions of sources and sinks on the lower and upper surfaces respectively, to make the resultant flow velocity tangential to the surface of the airfoil. Formulas for the force and moment on the airfoil are given. In the second part, similar procedures are applied to the case of a lattice of thin airfoils. In particular, explicit expressions are obtained for a lattice of airfoils with parabolic shape.

Isao Imai, Japan

Compressible Flow, Gas Dynamics

(See also Revs. 1520, 1529, 1533, 1538)

1523. S. V. Falkovich, "On the theory of the Laval nozzle," *Nat. adv. Comm. Aero. tech. Memo.*, no. 1212, Apr. 1949, 16 pp. (transl. from *Appl. Math. Mech. Prikl. Mat. Mekh.*), 1946, vol. 10, no. 4, pp. 503–512).

The author studies the motion of a gas in a plane Laval nozzle (two-dimensional) in the neighborhood of the transition from subsonic to supersonic regions. The method of attack is based on the transformation of the equation of motion and continuity to a form called by the author the canonical form for the system of differential equations of the mixed elliptic-hyperbolic type, to which the system of equations of the considered type of motion of an ideal compressible fluid reduces. By studying the behavior of the integrals of this system in the neighborhood of the parabolic line, the principal term of the solution is easily separated out in the form of a polynomial of the third degree. An analysis of the mathematical solution leads to the conclusion that the point of intersection of the axis of symmetry of the nozzle and the sound line is a singular point. The Frankl results, published previously, are thus obtained by a simpler method. The computation of the transitional part of the nozzle may be considerably simplified.

M. Z. Krzywobłocki, USA

1524. F. K. Bannister and G. F. Mucklow, "Wave action following sudden release of compressed gas from a cylinder," *Proc. Instn. mech. Engrs.*, 1948, vol. 159, no. 42, pp. 269–300.

The methods of unsteady one-dimensional gas dynamics give a rather clear insight into the phenomena which occur in the exhaust system of a reciprocating engine. The authors experimentally and theoretically investigate the flow which arises in pipes of considerable length (up to about 40 ft) with a bore of 2 in. when a membrane which separates this pipe from a space with a higher pressure is pierced by a needle.

First the experimental equipment, especially the pressure recording devices, are described. Then a theoretical analysis of the flow is given and the essential details of the flow pattern are discussed (shock fronts, rarefaction and compression waves, and the influence of the friction of the walls, for two different forms of the friction law). As is pointed out in the comments given at the end of the paper, the concept of characteristics gives a somewhat more general picture of the flow pattern. (Reviewer's remark: With the aid of the method of characteristics one can even include the friction at the walls).

The experimental results are then given and compared with the theoretical prediction. The significance of the present paper lies in the fact that it gives a new application of an otherwise known method of computation. The comments given at the end add further emphasis to the engineering aspects.

Gottfried Guderley, USA

1525. Carl Kaplan, "Effect of compressibility at high subsonic velocities on the lifting force acting on an elliptic cylinder," *Nat. adv. Comm. Aero. Rep.*, no. 834, 1946 (issued in 1949), 9 pp.

An extended form of the Ackeret iteration method, applicable to arbitrary profiles, is used to calculate the compressible flow at high subsonic velocities past an elliptic cylinder at small angles of attack. In the solution the stream function is expanded in the form $\psi = -U_y + \Sigma_1^\infty \psi_n(x, y)$ where it is assumed that ψ_{n+1} is small compared to ψ_n, and similarly for the derivatives of the functions ψ_n. This expression is substituted in the well-known differential equation for compressible nonviscous fluids, written in terms of the stream function. Terms of equal orders of magnitude are equated and the resulting linear partial differential equations are solved with the aid of a transformation in the complex domain. The Kutta condition on the circulation is enforced at the trailing end of the major axis of the cylinder.

The expression for the lifting force is derived and shows a first-step improvement on the Prandtl-Glauert rule. It is also shown that this expression, although derived specifically for an elliptic cylinder, is valid for any arbitrary symmetric profile as well. The result is

$$(L_c/L_i) = \mu + [(1 - e^{2\lambda})/2][\mu(\mu - 1) + (\gamma + 1)(\mu^2 - 1)^2/4]$$

where L_c and L_i are the lift forces for compressible and incompressible flows, respectively, λ is the thickness coefficient and $\mu = (1 - M^2)^{-1/2}$.

Bruno A. Boley, USA

1526. S. Kirkby and A. Robinson, "Wing body interference at supersonic speeds," *Coll. Aero. Cranfield Rep.*, no. 7, Apr. 1947, 18 pp.

The increase in the wing lift due to the normal velocities induced by the body on the wing is computed for a rectangular wing mounted aft of the nose of a cone. The linearized solution for the cone is used to determine the normal velocities induced in the plane of the wing. The Ackeret linearized solution is then used to compute the lift increment produced by this induced local angle of attack at the mid-chord line. This assumes that Ackeret's formula applies at each mid-chord point independently of the conditions elsewhere along the span (strip theory).

The use of the simple Ackeret formula along the mid-chord is partially justified by showing that in two particular cases the same value is obtained when the lift increment is computed by integrating the linearized equations over the entire wing area. The two exact linearized solutions which are considered are for a linear variation and an inverse-square variation of the spanwise distribution of the induced normal velocities.

E. V. Laitone, USA

Turbulence, Boundary Layer, etc.

1527. Harumi Asao, "A solution for the boundary layer along a flat plate" (in Japanese), *Trans. Soc. mech. Engrs. Japan*, May 1947, vol. 13, no. 44, pp. 41–47.

The velocity in the boundary layer along a flat plate can be expressed as (A): $u = (2a_1)^{1/3}[z - z^4/4! + 11z^7/7! - 375z^{10}/10! + \ldots]$, $z = (a_1 12)^{1/2} y x^{-1/2}$. The author proposes the approximate expression (B): $u = \frac{1}{3} 2^{1/3} a_1^{2/3} \int_0^z [\exp(-\lambda_1 z^3) + \exp(-\lambda_2 z^3) + \exp(-\lambda_3 z^3)] dz$, where λ_1, λ_2, λ_3, and a_1 are to be determined so that (A) and (B) coincide up to the term of z^{10}, and $u \to 1$ as $z \to \infty$. This results in values of $\lambda_1 = 0.24688$, $\lambda_{2,3} = 0.12656 \pm 0.02567i$, $a_1 = 0.3337$. The differences of the values of u as calculated by (B) from those given by S. Goldstein [*Modern Developments in Fluid Dynamics*, 1938, p. 136] are less than 0.6 per cent throughout the boundary layer $0 < z < \infty$. In particular, Goldstein's a_1 is 0.33206.

Isao Imai, Japan

1528. Theodore von Kármán, "Progress in the statistical theory of turbulence," *Proc. nat. Acad. Sci. Wash.*, Nov. 1948, vol. 34, pp. 530–539.

This paper first surveys the early progress of the statistical theory of turbulence with the purpose of defining the problem clearly and pointing out the relations between the assumptions made and the results obtained. The main features of the spec-

tral theory of turbulence are described; it is shown clearly that an assumption must be made to determine the transfer of energy, that is, the relation between the transfer rate $W(\kappa)$ at wave number κ with the spectrum $F(\kappa)$, and that κ cannot be determined from the present theoretical knowledge. Thus, in the equation for energy transfer

$$\partial F/\partial t + W(\kappa) = -2\nu\kappa^2 F(\kappa),$$

where t is the time and ν is the kinematic coefficient of viscosity, we have the same indeterminacy as in the von Kármán-Howarth equation for the propagation of correlation function.

General forms for the transfer function are proposed. These are then restricted to the following forms involving two arbitrary constants α and β and a constant of proportionality C:

$$W(\kappa) = C[F^{3/2-\alpha}\kappa^{1/2-\beta} {}_{\kappa}\int^{\infty} F^{\alpha}(\kappa')\kappa'^{\beta} d\kappa' - F^{\alpha}\kappa^{\beta} {}_{0}\int^{\kappa} F^{3/2-\alpha}(\kappa')\kappa'^{1/2-\beta} d\kappa'],$$

$$W(\kappa) = C[F^{3/2-\alpha}\kappa^{1/2-\beta} {}_{\kappa}\int^{\infty} F(\kappa')^{\alpha}\kappa'^{\beta} d\kappa' - F^{\alpha}\kappa^{\beta} {}_{0}\int^{\kappa} F(\kappa')^{3/2-\alpha}\kappa'^{1/2-\beta} d\kappa'.$$

It is pointed out that with such a relation the behavior of the spectrum is completely determined by its initial form. It is shown that this form includes Heisenberg's assumption as the special case $\alpha = 1/2$, $\beta = -3/2$, and that it leads to the negative 5/3 power law for the spectrum.

The law of decay is discussed with Loitsiansky's condition, which is the fourth-power law for the spectrum at small wave numbers. The interpolation formula

$$\kappa_0 F(\kappa)/u^{2*} = \Phi(\xi) = \text{const} \frac{\xi^4}{(1 + \xi^2)^{17/6}}$$

(where u^{2*} is the mean square of the velocity fluctuation) is suggested for the spectrum ($\xi = \kappa/\kappa_0$, κ_0 being some reference wave number), so that it behaves as the fourth power of the wave number at extremely low frequencies, and as the $-5/3$ power at high frequencies. Furthermore, it has been so chosen that the calculations of the one-dimensional spectrum and correlation function can be easily made. The latter is expressed in terms of modified Bessel functions of order 1/3. Thus, the lateral correlation coefficient is

$$g(\kappa_0 r) = \frac{2^{2/3}}{\Gamma(1/3)} (\kappa_0 r)^{1/3} [K_{1/3}(\kappa_0 r) - \tfrac{1}{2} \kappa_0 r/K_{-2/3}(\kappa_0 r)].$$

The calculated curves are compared with the experimental results of Liepmann-Laufer-Liepmann and found to be in close agreement. Kovasznay's proposed relation for energy transfer is also discussed.

C. C. Lin, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 1526, 1536, 1554)

1529. M. A. Heaslet and H. Lomax, "Two-dimensional unsteady lift problems in supersonic flight," *Nat. adv. Comm. Aero. tech. Note*, no. 1621, June 1948, 26 pp.

The linearized equations for unsteady two-dimensional supersonic flow are solved for the cases of an airfoil entering a gust, and undergoing a sudden increase of angle of attack. The first of these has also been solved by Chang [*J. aero Sci.*, Nov. 1948] by a more complicated method, while the second has also been solved by Biot [*J. aero. Sci.*, May 1949] by methods essentially similar to those of the authors.

The method of solution is that of reducing the equation for the potential function in unsteady flow referred to coordinates fixed in the airfoil to the two-dimensional wave equation referred to coordinates fixed in the fluid. The solution to any particular problem is then constructed from elementary source solutions of the wave equation. The analogy between the two-dimensional wave equation and the equation for three-dimensional steady supersonic flow is utilized to show the three-dimensional steady-flow problems which are the counterparts of the two-dimensional unsteady flow problems under consideration. These steady-flow problems are both problems of determining the loading on the tip of a sweptforward wing with constant chord and a supersonic leading edge.

It is pointed out that the basic differential equation is not limited to supersonic flight speeds, being also applicable to the subsonic case. In this case, the analogous steady-flow problem is one involving the tip of a sweptforward wing of constant chord with subsonic leading and trailing edges. A result is obtained for the starting lift coefficient of the airfoil following a sudden change of angle of attack. This result, $C_l = 4\alpha/M$, obtained by both impulse and energy methods, is applicable to subsonic as well as supersonic flow.

The results obtained are applied to the determination of the motion of an unrestrained airfoil in a gust, neglecting pitching motion. This problem leads to an integral equation of the second kind, with variable upper limit. Solutions are obtained by successive approximations, and presented by curves for a range of airplane-density parameters.

A. H. Flax, USA

1530. Helmut Heinrich, "Development of parachutes for bombs, mines, and torpedoes," *David Taylor Model Basin Rep.*, no. 215, Jan. 1949, 45 pp.

The paper describes the research and development required to develop a small, light, stable parachute which opens quickly without great shock. The stability investigation produced two new types: the Madelung Ribbon Chute and the Heinrich Control Chute. The pendular motion of the normal hemispherical chute is caused by one-sided unseparated flow produced by lateral air currents. The flow adherence is prevented either by allowing some air to flow through a porous chute, or by the use of truncated-cone control aprons off the bottom of the nonporous chute. The porous chute is essentially a stabilized, high-drag chute, while the control chute is essentially a highly stabilized lower-drag chute; both have lower drag than the normal chute.

The shock and quick-opening investigations were carried on very successfully with model gun-projected chutes and by means of wind-tunnel tests; in both cases high-speed spark photography was used. Only results on high chute loadings were available at the reporting time. The standard chute had a measured shock-force factor of 2, a familiar figure in shock-loading problems, while the factor for the Heinrich chute was only 1.25. An essentially shockless chute design is also presented. The ranges of application of the new chute types are discussed. They include personnel and wide military applications.

M. G. Scherberg, USA

1531. J. Richard Spahr, "Lateral-control characteristics of various spoiler arrangements as measured in flight," *Nat. adv. Comm. Aero. tech. Note*, no. 1123, Jan. 1947, 53 pp.

This describes a flight investigation of the lateral control characteristics of several spoiler arrangements near the wing trailing edge, including circular arc, zap-type and flap-type spoilers. The rolling effectiveness varied with control deflection smoothly and nearly linearly. For a given control deflection it increased with air speed, in contrast to the usual decrease with aileron control (tests were made up to a Mach number of .68). This was

attributed to the smaller aeroelastic effect and improved effectiveness with decrease in angle of attack and increasing Mach number of spoilers. The yawing tendencies of the spoilers were more favorable than those of ailerons. The control forces varied at an increasing rate with control deflection, giving a low degree of control feel at small deflections. A small wing-tip aileron with the spoiler gave satisfactory control force characteristics. The change in normal acceleration with spoiler deflection, due to loss of lift, was not noticeable at low speeds and not objectionable at high speeds. A. H. Flax, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See Rev. 1529)

Propellers, Fans, Turbines, Pumps, etc.

1532. W. Siegfried, "Creep tests and their application to gas-turbine design" (in English), *Sulzer tech. Rev.*, 1948, no. 4, pp. 21–33.

This paper discusses the requirements placed on heat-resisting materials by gas-turbine designers, and practical methods for determining strength over long periods of service. Tests have indicated a correlation between brittleness and creep rate for many heat-resisting steels. The discussion is primarily from the point of view of the designer of marine and stationary power plants, and, as the author points out, the problems of an aircraft designer are so different as to radically alter material selection criteria. Data are presented on a Cr-Si-Mo steel, Timken 16/13/3 steel, 18-8 stainless, and other special steels.

Morton B. Millenson, USA

1533. M. C. Huppert and Charles MacGregor, "Comparison between predicted and observed performance of gas-turbine stator blade designed for free-vortex flow," *Nat. adv. Comm. Aero. tech. Note*, no. 1810, Apr. 1949, 55 pp. and 6 loose charts.

The results of flow measurements in a sector of an annular cascade are compared with those calculated by means of an approximate iteration procedure which is a development of Flügel's method of graphical integration of the flow equations. For the blades investigated, the calculation surface velocities agree satisfactorily with the experimental values.

Joseph V. Foa, USA

1534. R. Kling and R. Jean, "Graphical study of the functioning of pumps and injectors for internal-combustion engines" (in French), *Rech. aéro. Paris*, Nov.-Dec. 1948, no. 6, pp. 15–22.

A graphical method, based on the equations of wave propagation, is used for the study of the complex fuel pump-pipe-injector system of an internal-combustion engine, and the determination of the pressure and flow rate at the exit. The influence of the motion of the injector needle and of the dead spaces and valve resistance is discussed. Gino Moretti, Argentina

Flow and Flight Test Techniques

(See also Rev. 1524)

1535. R. S. Swanson and T. A. Toll, "Jet-boundary corrections for reflection-plane models in rectangular wind tunnels," *Nat. adv. Comm. Aero. Rep.*, no. 770, 1943 (publ. in 1947), 28 pp.

In this paper a method is presented in considerable detail for calculating corrections due to the influence of jet boundaries on reflection-plane models in rectangular wind tunnels. The method is based primarily on the determination of the aerodynamic force and moment increments which would occur when the model is assumed twisted through an angle equivalent to the upwash angle induced by the presence of the boundary.

The report includes calculations of: (a) span load distribution; (b) corrections to the angle of attack, lift and drag coefficients; and (c) the pitching, rolling, yawing, and hinge moment coefficients. Both symmetric and asymmetric body conditions are considered. Numerical examples of the probable corrections are worked out for reflection-plane models in a closed-throat wind tunnel with a 7 × 10-ft cross section. Tables giving numerical value of the upwash induced by the jet boundaries are included for this specific size of throat; the method may be applied to any size of rectangular throat. Frank L. Wattendorf, USA

1536. M. A. Garbell, "Fins for aerological instruments," *J. Met.*, June 1947, vol. 4, pp. 82–90.

The paper discusses theory and design of fluid-flow-direction indicating instruments, and contains much information of interest to those concerned with the design of vane-type angle-of-attack and angle-of-sideslip indicators.

The equations of motion for a simple mechanical system composed of a mass rotating under the influence of viscous damping and elastic restraint are written for the vane motion, and the familiar forms of solution are set down. The static stability and damping parameters are thus expressed in terms of hinge-moment and inertia characteristics. The hinge moment is then expressed in terms of fin-lift-curve slope, aspect ratio, and pertinent geometric characteristics. This is done for two eccentrically located fins, for symmetric airfoils (a) with, and (b) without toe in, and for (c) cambered airfoils with toe in.

The case (a) offers advantages in increased static stability and damping, at the expense of increased drag. Toed-out fins are not recommended because of their destabilizing contributions at large yaw angles. The case (b) has the same characteristics as a single centrally located fin of area equal to the total. It is better however where the local velocity V_f for a central fin is less than the free-stream one, V. In this case the two fins should be located so that $(V_f/V)^2 \cos\theta$ be a maximum, where θ is the eccentricity angle. This will eliminate flat spots in the fin-lift curve which will occur if θ is less than optimum. The damping characteristics of this configuration are determined primarily by the lift forces and will be a maximum for minimum θ. Case (c) shows no significant improvements over symmetric fins unless sections are selected which have a sharp increase in profile drag coefficient at angles of attack just below that for zero lift. The rotary damping becomes nonlinear and increases sharply for large yawing angles. This may be useful for reducing rotational inertia, to decrease response time without sacrificing desirable dynamic characteristics.

The paper concludes with suggestions for optimum design configurations for several flow-direction measuring instruments.

David W. Whitcomb, USA

Thermodynamics

⊗1537. H. C. Hottel, G. C. Williams, and C. N. Satterfield, "Thermodynamic charts for combustion processes. Part 1, text; Part 2, charts," John Wiley & Sons, Inc., New York, 1949. Paper, 8.8 × 11 in., total pages 98, figs. 41, charts 15, \$5.

The charts presented are: (1) A "modified-air chart," which consists of a pressure-volume-temperature-entropy plot for pure air, with auxiliary curves permitting its application to typical fuel-air mixtures or combustion products. Gas imperfections are

included by use of the Beattie-Bridgeman equation and the Dobratz relation for zero-pressure conditions, but dissociation is not considered. (2) Seven "burned mixture charts," which in effect extend chart (1) up to the higher temperatures at which dissociation cannot be neglected. (3) Six "generalized thermodynamic charts" giving the properties of equilibrium mixtures of carbon, hydrogen, nitrogen, oxygen, and their compounds up to very high temperatures.

The value of the charts is greatly enhanced by the detailed account of their preparation, and by the excellent illustrative examples of their use, which cover most of the applications of the charts to modern power units such as ramjets, gas turbines, and rockets. The accompanying bibliography is unusually extensive. It is unfortunate that the charts have been constructed with differing temperature bases for zero enthalpy, so that confusion can arise if they are used jointly. R. Smelt, USA

1538. Frank R. Caldwell, Filimer W. Ruegg, and Lief O. Olsen, "Combustion in moving air," *Soc. auto. Engrs. J.*, Feb. 1949, vol. 57, 23 pp.

This paper is a very good collection of the basic thermodynamic, aerodynamic and pyrogenic facts concerning combustion that have been established to date. The paper attempts to integrate and correlate this information. Examples are given showing the effect on combustion performance of varying air-flow velocity, temperature, pressure type of fuel injection and combustion design.

The material presented is very useful in understanding the various phenomena connected with the combustion process. This paper should prove helpful to the newcomer in the field of combustion. C. A. Meyer, USA

Heat Transfer; Diffusion

(See also Revs. 1477, 1485, 1558)

1539. H. C. Hamaker, "Radiation and heat conduction in light-scattering material" (in English), *Philips Res. Rep.*, 1947, vol. 2: Feb., pp. 54–67; Apr., pp. 103–125.

Differential equations developed in 1905 by Schuster are applied to the calculation of the total amounts of light or of thermal radiation absorbed, reflected, and transmitted by layers of light-scattering materials. The variation in the intensity of a beam as it traverses a layer is made up of a loss of energy due to absorption and scattering into other directions, with a gain of energy due to scattering of other beams. The formulas developed are used to describe the luminescence of fluorescent screens excited by X-radiation or electron bombardment, and the reflection of light from semi-infinite or finite layers.

The theory is extended to include simultaneous heat conduction and radiation within a light-scattering and absorbing layer in which the temperature varies. The radiation intensity is assumed to be linear in the temperature. A hot cathode coated with a layer of metal oxide radiates not only from the oxide surface but also from the interior of the oxide, where the temperature may be higher.

When the surface emissivity is used to compute the surface temperature of a filament in which a temperature gradient is present, errors of the order of 10 K may occur, the true temperature being lower than that estimated from the observed radiation. The temperature varies linearly with the distance only near the center of a layer. Near the surface the profile is curved, due to the interplay of conduction and radiation outward from the material just under the surface. In determinations of the thermal conductivity of a metal oxide layer the assumption of a linear temperature gradient throughout the solid leads to an error. R. L. Pigford, USA

1540. M. Jakob, "Temperature distribution in some simple bodies developing or absorbing heat at a linear function of temperature," *Trans. Amer. Soc. mech. Engrs.*, Jan. 1948, vol. 70, pp. 25–30.

This paper is a supplement to an earlier paper by the author [*same source*, 1943, pp. 593–605] in which the temperature distribution in a plate, cylinder and sphere with constant surface temperature and a heat source which increases with the temperature of the body was investigated. In the present paper the author analyzes the opposite case of the heat source which decreases with the temperature of the body. Like the earlier case, it is analyzed for the steady state only.

While the differential equations and boundary conditions are identical in both cases, the solutions are now different, owing to the change in sign of the temperature coefficient of the heat source. The curves representing the temperature as a function of the distance from the center line are similar to those obtained for the positive temperature coefficient, and are separated from them by the parabola representing the constant heat source, as indicated in figures 1, 3 and 4 of the previous paper. The solutions given are applicable to both positive and negative heat sources. The deviations from the case of the constant heat source are more pronounced for the negative than for the positive temperature coefficient. Eric F. Lype, USA

Acoustics

1541. M. D. Haskind, "Propagation of sound through a slit in subsonic and supersonic gas flow" (in Russian), *J. tech. Phys. (Zh. tekh. Fiz.)*, July 1947, vol. 27, pp. 693–698.

The propagation of a plane sound wave through a slit in an infinite plane moving at subsonic or supersonic speeds is considered. In the first case the potential for the diffracted wave is given in elliptic coordinates as a series of Mathieu functions. In the second case the equation for the potential function reduces to the telegrapher's equation, and the potential for the diffracted wave may again be given explicitly. J. V. Wehausen, USA

1542. D. Cameron and W. J. D. Annand, "Measurements of cabin noise in bomber aircraft," *Rep. Memo. aero. Res. Counc. Lond.*, no. 2296, Jan. 1942, (issued in 1948), pp. 1–20.

This is a rather "dated" report on early, tentative studies of cabin noise in aircraft and the effect of soundproofing. Curves of noise level in db (reference level not specified, but presumably minimum audible) plotted against frequency from 10 to 10,000 cycles, were obtained for eight bomber airplanes. The principal sources of noise appear to be propeller rotation and engine exhaust at low frequency and aerodynamic noise at high frequency. Soundproofing techniques were rather primitive by present standards and the results not very conclusive.

R. B. Lindsay, USA

Soil Mechanics, Seepage

1543. W. G. Holtz, "The determination of limits for the control of placement moisture in high rolled-earth dams," *Proc. Amer. Soc. Test. Mat.*, 1948, vol. 48, pp. 1240–1248.

The author states that in rolled-earth fill construction it is not satisfactory simply to try to obtain maximum density at optimum

moisture, but one must rather seek a compromise between consolidation and saturation if too dry, and weakness due to excessive pore pressure if too wet. A laboratory method of control developed by experience is outlined and illustrated with an example of test procedures and results.

Samples are tamped-in consolidometers at several moisture contents, using energies equivalent to field compaction. For each moisture, samples are consolidated under several loads covering the range to be encountered in the fill; further volume change due to inundation is then determined. The lower limit of permissible placement moisture is determined by the water required to prevent increased consolidation due to inundation. The pore pressure for no drainage is calculated from the air and water content and volume change of the samples before inundation by a formula which considers the solubility of air and water. The upper limit of permissible placement moisture is determined by choosing an allowable pore pressure expressed as a percentage of the applied pressure.

By applying external pressure to an undrained sample sealed in a thin rubber sleeve, and recording internal pore pressure with no-flow pressure cells, checks have been obtained on calculated pore pressures which are usually used. Edward S. Barber, USA

1544. J. Ferrandon, "State of limit equilibrium of filtering masses" (in French), *Génie civ.*, June 15, 1948, vol. 125, pp. 230–232.

The aim of this paper is to give an indication of the necessary modifications in the usual procedures for the limiting states of equilibrium of soil masses to take into account the forces produced by seepage of water. The general equations derived are, however, practically impossible to solve except in a few simple cases for which the author gives a summary of the results.

N. M. Newmark, USA

1545. E. De Beer, "Measurements of stress distribution in the contact face. Tests for the determination of the distribution of soil reactions underneath beams resting on soil" (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 2, pp. 142–148.

Strains were measured by electric-resistivity strain gages at the extreme lower fiber of the central section of a loaded steel beam resting on sand. The measured values are compared to values computed on the basis of three different assumptions concerning the distribution of soil reactions against the beam.

G. P. Tschebotarioff, USA

1546. E. De Beer, "Computation of beams resting on soil" (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 1, pp. 119–122.

A method of obtaining a general solution to the problem of a beam supported on soil is presented in this paper. The general solution is obtained by assuming arbitrary distributions of soil-beam reactions satisfying conditions of statics, and then adjusting the distribution until the deflections of the beam and the settlement of the soil surface at the interface are compatible.

A comparison is made of the results obtained by this method for the case of beams supporting concentrated, vertical, central loads with those obtained by the method involving the use of the modulus of subgrade reaction. The results of this investigation show that the method employing a modulus of subgrade reaction, wherein it is assumed that the soil has the properties of a perfect liquid, leads to a computed value of the maximum bending moment which differs appreciably, but not significantly, from that obtained by the general method. It is shown that the greater the relative stiffness of a beam with respect to that of the soil supporting it, the smaller the value of the moment at the center of the beam as computed by the modulus of subgrade reaction procedure, as compared with that obtained by the general and more realistic method described by the author. In the case of rectangular beams supporting a single concentrated load at their centers, the maximum moment as computed by the modulus of subgrade reaction procedure is shown to be never more than 30 per cent smaller than the "exact" value. R. E. Fadum, USA

1547. J. Jáky, "Pressure in silos" (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 1, pp. 103–107.

On the assumption that the material stored in a silo has internal friction but no cohesion, and that the horizontal and vertical shear stress follows certain empirical laws, the author solves for the distribution of stresses within the silo. A numerical example illustrating the use of the derived equations is given.

Gerald Pickett, USA

1548. J. Jáky, "On the bearing capacity of piles" (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 1, pp. 100–103.

The author assumes that for piles driven to a depth h or greater, a bearing bulb is developed. The bulb results from extending the meridian of the sliding surface upward until it terminates on the pile at the distance h above the bottom of the pile. This is accomplished by extending the logarithmic spiral portion of the sliding surface through 180 deg rather than only 90 deg.

On these assumptions, and by neglecting the weight of the soil and the skin friction above the pressure-bulb zone, the author derives a formula for bearing capacity. The author believes that within certain limiting pile depths, his formula gives much better results than other existing formulas. Gerald Pickett, USA

1549. René Deguillaume, "Apparatus for dynamic test of soils in situ" (in French), *Génie civ.*, Feb. 1, 1949, vol. 126, pp. 49–50.

The author computes values of the elastic limit load q_0 for a soil whose angle of internal friction is ϕ, cohesion c and density Δ, using an expression based on Froehlich's formula. For a circular foundation whose depth t is large compared with the radius of the foundation, this expression is

$$q_0 = \frac{c \cot \phi + \Delta t}{\frac{1}{2}\frac{1 + \sin \phi}{\sin \phi}\left(\frac{1 + \sin \phi}{3 - \sin \phi}\right)^{1/2}}$$

He shows that values of q_0 computed from the above equation compare very favorably with those obtained from dynamic and laboratory soil tests conducted by two independent investigators.

Eben Vey, USA

1550. H. Kastner, "The earth pressure on sustaining walls as a plane stress problem" (in German), *Öst. Ingen.-Arch.*, Jan. 1949, vol. 3, no. 1, pp. 77–91.

It is well known that Coulomb's theory of the lateral earth pressure on retaining walls does not satisfy the general equations of equilibrium. Various methods have been proposed for correcting this discrepancy but they have been too complicated for practical application.

In this paper the author tries to establish the earth pressure on retaining walls for noncoherent soils by the use of a stress func-

tion, and based on the assumptions of sliding theory. Using the expressions for stress in polar coordinates from two-dimensional elasticity theory, and making use of the condition of limit equilibrium, based on Mohr's stress diagram, the author establishes a first approximation to a stress function which satisfies the boundary conditions. By developing this function into a Maclaurin series, he obtains a better approximation, and a direct application is made to the case of a vertical wall and horizontal earth surface. A simple formula is deduced from this and compared with the classical method of Coulomb. For effective earth pressure there is only a small difference in the results of the two methods, while for passive earth pressure the differences become greater for friction angles between wall and earth exceeding 20 deg. Aurel A. Beleş, Rumania

1551. E. Jacoby, "The earth pressure due to single (distributed and concentrated) loads" (in German), *Bautechnik*, Aug. 1948, no. 8, pp. 176–178.

The author gives an expression for the earth pressure against a vertical retaining wall for various combinations of line and point loads on the horizontal fill behind the wall. The formulas are based on the simple sliding wedge theory, and are intended to apply only to a granular material without cohesion. Consideration is given only to the ordinary theory, no empirical modifications being made as a result of observations, tests, or more elaborate theoretical study. N. M. Newmark, USA

Geophysics, Meteorology, Oceanography

1552. B. Duell and G. Duell, "The behavior of barometric pressure during and after solar particle invasions and solar ultraviolet invasions," *Smithson. misc. Coll.*, Aug. 5, 1948, vol. 110, no. 8, 34 pp.

In part I the influences of particle invasions from the so-called M-regions of the sun upon the sea-level pressure are investigated by a simplified correlation ("superposed-epoch") method. For the period 1906–1937 the average behavior of the sea-level pressure for 26 European stations is calculated in the vicinity of special key-days, defined as days with especially high or low sun activity, measured by the geomagnetic activity. An influence could be demonstrated only for the winter months in years with low sun activity. Synoptic charts for the period from one day before to eight days after the geomagnetic storm show clearly the influence on barometric pressure. On the second day there is a relative pressure maximum of 2.5 mb over Iceland and a minimum of 2.5 mb over the Baltic States. As the occurrence of these particle invasions can be predicted fairly well, it may be possible after further investigations to use this knowledge to help weather forecasting.

In part II a similar influence on the pressure, equal for the whole year in this case, is shown from solar ultraviolet (UV) invasions which occur during bright chromospheric eruptions. The statistical investigation is based o.. data from the years 1936–1941, the method being the same as in part I. There is a well-developed relative pressure maximum 4 to 6 days after an UV invasion.

The authors list the possible causes of these effects, which are to be investigated in future research, as: (a) for the influence of particle invasions: transfer of kinetic energy, heating and expansion of layers in the ionosphere, production of condensation nuclei, electroconvection; (b) for the influence of UV invasions: expansion of ionospheric layers due to O_2 dissociation and heating, influence on the ozone layer, production of condensation nuclei. Horst Merbt, England

1553. R. W. James, "Translation and development in two-dimensional fields, with special reference to pressure variations," *Austral. J. sci. Res. Ser. A*, Dec. 1948, vol. 1, no. 4, pp. 412–422.

The author discusses the problem of weather forecasting by a kinematical analysis of the observed pressure and temperature fields, following essentially the methods developed by Petterssen. He suggests that the motion of dominant features of a pressure field, such as a low, may be best discussed by a statistical analysis of the observed quantities. For example, he considers the motion of a low to be composed of a translation plus a rotation, and the three parameters involved are determined by a least-squares procedure from the computed velocities of the isobars in the neighborhood of the low. The procedure is not essentially different from that proposed by Petterssen, since the Petterssen analysis was based on the use of faired quantities for determining the required derivatives. H. J. Stewart, USA

1554. Alun R. Jones and William Lewis, "Recommended values of meteorological factors to be considered in the design of aircraft ice-prevention equipment," *Nat. adv. Comm. Aero. tech. Note*, no. 1855, Mar. 1949, 14 pp.

Recommendations are presented for values of liquid water content and water-droplet size for use in the design of ice-prevention equipment for aircraft. For the purpose of discussion, the icing conditions are classified in four main classes, three concerned with certain cloud structures, the fourth with freezing rain. The recommendations are based upon both observation and theory. Myron Tribus, USA

1555. J. Zahradníček, "Form and mass of the earth" (in Czech), *Publ. Fac. Sci. Univ. Masaryk (Sp. Prir. Fak. Masaryk Univ.)*, no. 286, 1947, 16 pp.

Taking into consideration terms of the second order, the author first computes the flattening of the earth from Clairaut's equation, using for the great axis the value given by Hayford and for the gravitational acceleration the value accepted by UGGI in Stockholm (1930). The computed value $\epsilon = 1/297.3$ differs by only $^1/_{10}$ of a per cent from the value given by Hayford. Accepting as the most probable value for the Newton gravitational constant $\chi = (6.667 \pm 0.005)\ 10^{-8}$ abs un (obtained as the mean of the measurements made by six different authors from 1889 to 1927), he finally obtains for the mass of the earth $M = (5.979 \pm 0.004)\ 10^{27}\ g$, a value different from that accepted at the meeting of UGGI in Madrid (1924). Z. Sekera, USA

1556. George F. McEwen, "The dynamics of large horizontal eddies (axes vertical) in the ocean off Southern California," *J. Mar. Res.*, Nov. 1948, vol. 7, pp. 188–216.

A striking feature of the charts of horizontal circulation of the ocean in the Southern California region, lat 32 deg to 34.5 deg N, is a large counterclockwise eddy between a northward inshore current and a southward offshore current. Charts arranged in time order, starting from the spring, suggest that such eddies may be successive stages in the decay of an initial stage of maximum intensity and of relatively small area. In order to simplify the dynamical problem, equivalent circular eddies are derived by averaging the velocities of the actual oval-shaped ones, and the investigation deals with these circular eddies.

Their kinetic energy was found to decrease. The author shows that an estimate of the eddy viscosity of a circular eddy is possible (formula 6, page 201). This yields values for the eddy viscosity ranging from 3×10^4 to 6×10^5 cgs. From the generally accepted differential equations of motion of the ocean, the author

shows that for purely horizontal motion, and under the simplifying assumption that $2\Omega\sin\varphi$ = constant in the region considered (Ω being angular velocity of the earth, φ latitude), the vorticity of a circular eddy satisfies the equation of heat conduction, with the square of the eddy-viscosity coefficient taking the place of the heat-conduction coefficient. The integration of this equation for the observed initial condition is found to agree acceptably with the observed changes in such eddies. Paul Neményi, USA

1557. Jörgen Holmboe, "On dynamic stability of zonal currents," *J. Mar. Res.*, Nov. 1948, vol. 7, no. 3, pp. 163–174.

This paper concerning circular vortices around the poles is an interesting exercise in the use of vector methods in a symmetric perturbation problem, but owing to the extreme simplification of the model has little application. Furthermore, the techniques are generally well known and lead rather to further understanding of previous results than to new tools or explanation.

Joanne Starr Malkus, USA

1558. Renichi Saito, "Depletion of radiation in a diffusely reflecting medium" (in Japanese), *J. met. Soc. Japan*, Aug. 1948, vol. 26, pp. 208–215.

The depletion of the radiation in doubly-layered homogeneous mediums is treated theoretically and the coefficient of depletion obtained. The result may be generalized to a multiply-layered medium. S. Syōno, Japan

Lubrication; Bearings; Wear

(See also Rev. 1484)

1559. Robert Schnurmann, "Thermoelectric experiments with extreme-pressure lubricants," *J. appl. Phys.*, Apr. 1949, vol. 20, pp. 376–383.

Extreme-pressure lubricants (EPL) are designed to reduce friction at high pressures, and prevent abrasion of the surfaces of the rubbing elements. The teeth of hypoid gears are subjected to pressures up to 1.5 to 3×10^4 kg per cm^2.

For testing EPL the author employs a device in which a rotating steel ball ($^3/_8$ in. diam) is pressed against the flat surface of a metal block (Timken test block, flat surface of a steel roller, etc.). The thermal electromotive force generated at this contact is taken as a measure of friction. If lubrication is insufficient, abrasion takes place and the galvanometer reading increases at a greater rate than the normal load. With pure mineral oil at 18 rps, for instance, the electromotive force was proportional to the normal load only up to a load of 80 kg. The addition of 2 per cent by volume of chlorinated paraffin wax extended this region of proportionality to a load of more than 128 kg. The final wear impression had a diameter in the first case of 1.61 mm, in the latter of only 0.79 mm.

The author employs EPL of various kinds, with different concentrations and several metals and metallic films. The results suggest the existence of an optimum concentration of additive. The author makes an attempt to explain this fact physically.

Hans Drescher, Germany

1560. N. Soda and Y. Miyakawa, "On the mechanical transition temperature (Fundamental studies on the combination of bearing metals)" (in Japanese), *Rep. Inst. Sci. Technol. Tokyo*, Jan.-Feb. 1948, vol. 2, pp. 23–30.

D. Tabor has reported [*Nature*, May 17, 1941, vol. 147, p. 609] that the mechanical transition temperatures of thin films of saturated fatty acids are higher than their melting points by about 75 C. The authors determined by stick-slip analysis the transition temperatures for various combinations of rubbing metals, and found that such a simple relation does not generally hold. The mechanical transition temperatures increased linearly with the number of carbon atoms in the molecules and, for a steel slider and steel plate, the temperatures coincided approximately with those determined by the electron-diffraction method. For other combinations of rubbing metals, however, the mechanical transition temperatures were lower than the transition temperatures from electron diffraction, the difference being nearly independent of the number of carbon atoms and increasing as the dry friction of the rubbing metals increased. Itiro Tani, Japan

1561. N. Soda and Y. Miyakawa, "Molten metals as lubricants" (in Japanese), *Rep. Inst. Sci. Technol. Tokyo*, May-June 1948, vol. 2, pp. 80–90.

The fact that most lubricants lose their lubricating properties at high temperatures suggested to the authors that the so-called bearing metals of low melting point (lead, tin, cadmium, white metal, etc.) would melt on the bearing surface at high temperatures so as to serve as lubricant. The authors measured by stick-slip apparatus the friction for various combinations of slider and plate, with a thin metallic film covering the plate. A sudden drop of friction was observed at the moment when the temperature of the contact point reached the melting point of the metallic film or slider metal. For a steel slider and kelmet plate the drop of friction occurred at the melting point of lead. Also the friction characteristics changed from stick-slip to continuous sliding at the critical temperature. Itiro Tani, Japan

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Volume 2, January–December, 1949

(Serial numbers of reviews are given. In all cross references only the look-up words are capitalized. Some references, although not represented by any reviews in this volume, have been retained as leads to reviews in other volumes.)

Review Numbers	Issue
1–151	January
152–283	February
284–415	March
416–559	April
560–691	May
692–812	June
813–956	July
957–1084	August
1085–1219	September
1220–1344	October
1345–1472	November
1473–1561	December

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

Author Index to Applied Mechanics Reviews

Volume 2, January—December, 1949

(Numbers used are serial numbers of Reviews)

C

D

E

F

G

H

I

J

L

N

O

P

Q

R

S

T

U

V

Y

Z

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